Thirty years of Trust & Verify

The first edition of Trust & Verify came out in June 1989, three years after the charity had been established, as a response to the need for a 'regular bulletin dealing solely with verification'. The bulletin has been published throughout most of VERTIC's existence and is now in its 164th edition. This article seeks to capture broad developments in verification, implementation and compliance, as reported on the pages of Trust & Verify over the years.

The world was a very different place when the Centre first started to write about verification. In the East, communist government control over their populations was beginning to slip. It began in Poland that summer, with the trade union Solidarity winning the election in Poland. In the months that followed, reforms and upheaval would consume both Hungary and Czechoslovakia, the Berlin Wall would come down, and the dictatorship in Romania would come to a bloody end. These events started a chain reaction throughout the Eastern Bloc, moving so fast that contemporary observers would have had difficulty comprehending them. By Trust & Verify No. 17, the Soviet Union, a commanding force since 1945, had ceased to exist.

Of course, this was not the end of the transformation occurring in those remarkable years. In 1989, F. W. de Klerk was elected South African president. His government would start work to both dismantle apartheid and dismantle its nuclear weapons, work that would be completed by the time Nelson Mandela was elected president in 1994.

The demise of the Soviet Union would open up a decade of multilateral collaboration. Throughout this period, the world saw action on the environment through the adoption of the United Nations Framework Convention on Climate Change in 1992, the conclusion of negotiations on a comprehensive ban on chemical weapons in 1993, a complete ban on nuclear weapons testing in 1996, and the strengthening of nuclear safeguards in 1997.

The 1990s were also marked by a change in the socio-economic power of nations. At the start of the decade, the ten biggest economies were clustered in North America and Europe, with only Brazil and Japan being outside the transatlantic block. By 2000, China had joined those ranks, and its economic strength would continue to grow in the decades that followed. In Europe, work to achieve social and economic integration accelerated with the opening of the Treaty on European Union (also known as the Maastricht Treaty) in 1992 which established the largest trading bloc and integrated economy in the world.

With these profound changes, barriers to the movement of capital, trade and people fell. Moreover, the pace of digitalisation and the free exchange of data on the internet also meant that ideas, to a greater extent than ever before, were no longer constrained by borders. Since our first edition, the world has become more prosperous, better educated and more transparent. This change did not benefit all, however, with the countries of the former Soviet Union locked in a decades-long spiral of economic decline, and profound social changes elsewhere started to create a growing sense of disenfranchisement and discontent in many parts of both the developed and developing world.

Trust & Verify
Summer 2019 • Issue Number 164 • ISSN 0966–9221

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Tides: the United States and Russia

On 31 December 1999, Boris Yeltsin, the Russian Federation's first president, resigned. In a politically masterful move, he appointed Prime Minister Vladimir Putin acting president, prompting an election within three months, which caught the opposition woefully unprepared. Putin won in the first round with 53 per cent of the vote.

At first, most of the international community did not know what to make of the new president. The Economist, for instance, led its 6 January 2000 edition with an article entitled 'Putin the Great Unknown', warning that while he deserved the benefit of the doubt, the facts 'lean more towards doubt than benefit'. In terms of arms control, Putin got off to a good start. Even as Prime Minister, he had called on the United States to ratify the 1993 START II agreement. Under the agreement, covered in editions No. 35 and No. 91, the two countries would have pledged to reduce their arsenals to no more than 3,500 warheads.

However, this was not to be. US President George W. Bush was inaugurated on 20 January 2001, and he brought with him a whole new perspective on arms control. On 13 December 2001, President Bush announced the US withdrawal from the 1972 Anti Ballistic Missile Treaty. Due to continuing domestic opposition, President Bush never seriously pursued START II ratification. Instead, the United States and Russia, after only six months of negotiations, decided on a totally unverified new arms control agreement, the Strategic Offensive Reductions Treaty (SORT). While SORT went further than START II in terms of reductions, bringing the total arsenal on both sides down to between 1,700 and 2,200 operationally deployed warheads, it was cautiously welcomed on the pages of Trust & Verify. In edition No. 103, Nikolai Sokov wrote that SORT 'is one of the shortest arms control accords in history'. And while Sokov regrets the loss of transparency in the new agreement, he notes that 'the improved relationship between the two countries allows almost unlimited time for developing a transparency and verification regime' in the future.

Whatever respite Sokov foresaw, the relationship between the United States and Russia deteriorated significantly after edition No. 103 was published. Disagreements over missile defence and conventional forces in Europe, were followed in the present decade by radically different perspectives on Ukraine, Syria and the broader Middle East, adding to the slurry of mistrust and hostility.

The Obama administration brought verification back to bilateral arms control with the signature of the 2010 Strategic Arms Reduction Treaty, which further limited the number of deployed warheads to 1,550. Trust & Verify No. 129 quoted Pavel Podvig, who noted, 'What is important is that the treaty provides the public with a way to hold the US and Russian governments accountable for the nuclear weapons they possess … A strong mechanism of transparency and verification is much more important than any specific number of warheads that the treaty eventually will mandate'.

Watershed moments: the Iraq Wars

The 1990s began with a major armed conflict in the Middle East. On 2 August 1990, the Iraqi Army invaded and occupied neighbouring Kuwait, prompting a multilateral response not seen since the days of the Korean War. About seven months later, the invading forces had been roundly defeated by a coalition army led by the United States. On 3 April 1991, the UN Security Council adopted resolution 687, which decided that Iraq should destroy, remove or render harmless its 'weapons of mass destruction', ballistic missiles with ranges exceeding 150 kilometres, as well as related production facilities and equipment. The resolution also established a system of ongoing monitoring and verification of Iraq's compliance with this resolution.

In Trust & Verify No. 145, Gudrun Harrer reflected on the subsequent work of the United Nations Special Commission (UNSCOM), initially under the chairmanship of Swedish diplomat Rolf Ekeus, and the International Atomic Energy Agency (IAEA) Action Team, under the initial leadership of the Italian Maurizio Zifferero. The relationship between the newly-formed UNSCOM and the established IAEA come out in Harrer's narrative, noting that 'it is almost forgotten that in 1991, critics of the IAEA in the US administration had tried to keep the body out of the inspection process in Iraq. Some doubted not only the capability but even the will of the IAEA to aggressively investigate Iraq's nuclear ambitions'. She also, rightly, observes that 'the IAEA narrative about that issue and about that period, in general, has been almost extinguished from the public domain—or never arrived there in the first place'.

The claim that Iraq possessed weapons of mass de-

struction was an important justification for the Second Iraq War, that commenced on 19 March 2003. However, as had been highlighted in Trust & Verify several times in the run-up to war and, more importantly, by the verifying organisations themselves, there was little evidence that the country had these weapons.

The charged political climate made it difficult for inspectors to do their job. The United Nations Monitoring, Verification and Inspection Commission (UNMOVIC), headed by Swedish diplomat Hans Blix, had been given the mission, together with his former colleague from the IAEA, Director General Mohamed ElBaradei. While the IAEA's work continued not to receive the attention it deserved, all eyes were on Hans Blix. As former VERTIC Executive Director Trevor Findlay wrote in edition No. 105, 'Washington is watching [UNMOVIC] like a hawk for the first sign of incompetence, insouciance or appeasement of the Iraqis'. This put undue pressure on the mission since, as Findlay put it, UNMOVIC continued to 'require Iraq's co-operation to do its job and must not antagonise it unnecessarily, even though such an intrusive verification regime would test the patience of the most innocent of countries'.

Virtually unnoticed was ElBaradei's statement on 14 February 2003, that the Agency's 'experience in the nuclear verification shows that it is possible, particularly with an intrusive verification system, to assess the presence or absence of a nuclear weapon program in a state, even without the full cooperation of the inspected states'.

In the end, inspectors were not allowed to finish the job. The day before the bombs started to fall on Baghdad, they were lifted out of the country. After about a month of combat operations, the Saddam Hussein regime fell and the 'Iraq Survey Group', under US leadership, started to comb the country for illicit weaponry. However, as Ben Mines noted in edition No. 112, it emerged empty-handed. No weapons of mass destruction were ever found.

Mixed results and uncertainty:
Efforts to ban chemical weapons

Since the first edition, Trust & Verify has followed developments to comprehensively ban chemical weapons, and especially the discussions by non-governmental organisations that were held in parallel with government negotiations, as portrayed in issue No. 9.. The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction—better known as the Chemical Weapons Convention (CWC)—was opened for signature on 13 January 1993. Like all agreements, the Convention was a result of compromise: as Trust & Verify No. 31 noted, some governments issued 'reservations about some of the provisions'.

Some of these reservations were related to the 'watering down' of challenge inspection language. Much work had gone into defining how on-site inspections could be carried out in practice, culminating in a comprehensive report submitted by the United Kingdom (see issue No. 12). The United States maintained a 'maximalist approach' to verification, favouring inspections 'anywhere, anytime, no right of refusal,' until what Trust & Verify dubbed a 'policy reversal' in 1991 (see issue No. 22). Critics said that a prolonged notice of inspection (at the time seven days) would give transgressors enough time to conceal any illegal activity. The background to the controversy was partially due to Iraq's inability to demonstrate full cooperation with UNSCOM.

In issue No. 35, Trust & Verify highlighted the signature of this agreement, which, in the words of the bulletin, 'marked the culmination of 25 years of negotiations'. True to form, it also carried a supplemental pullout explaining the principal parameters of the agreement, which remains useful even today.

The Convention has now been in force for more than 20 years and has 193 state parties. In that period, 97 per cent of the world's declared chemical weapons stockpile has been verifiably destroyed. Yet, in recent years, the norm against chemical weapons have been repeatedly violated in Syria, Iraq, Malaysia and the United Kingdom. Trust & Verify No. 160 discussed recent attempts to attribute chemical weapons use in Syria to specific actors, and noted that the 'attribution of responsibility for violation of international laws of war and the norm against the use of poison remains politically sensitive and subject to immediate geopolitical interests'. Moreover, the use of a nerve agent on British soil may have repercussions for many years to come. Or as we wrote in the same edition, it may throw 'into doubt the completeness of Russia's declaration of its chemical weapons stockpile'.

In an address to the European Union's Non-Proliferation and Disarmament Consortium's meeting on 18 December 2018, Fernando Arias, the Director-General of the OPCW, held that 'addressing the re-emergence of chemical

weapons use is now one of the crucial defining tests of the OPCW'. He went further by emphasising that the 'identification of the perpetrators of chemical weapons use will be an important factor to deterring further use'.

Almost there: Banning nuclear testing

In the 1980s, VERTIC's work focused on remote sensing, nuclear materials, seismology and nuclear testing, space weapons, as well as conventional forces and arms control. At the time of the first edition of Trust & Verify, a ban on nuclear testing in all environments appeared some way off. This did not deter a group of states to convene in 1991 an amendment conference to the 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water in an attempt to make it comprehensive. Trust & Verify No. 17 described the conference as a 'classic example of parliamentary politics' in which 'the United States and the United Kingdom were compelled to organize and participate in a forum that they did not want to create. They were compelled to consider an arms control proposal that they did not want to see on the table'.

Five years later, Trust & Verify No. 69 marked the adoption of the 1996 Comprehensive Nuclear Test Ban Treaty. Over the lifetime of our publication, the treaty has been covered extensively, and this is probably worthy of a lead article in its own right. Consider, for instance, VERTIC's involvement in establishing the credibility of near-real-time monitoring, most recently described in edition No. 163.

Of particular note, however, are the findings of the 'The Independent Commission on the Verifiability of the Comprehensive Nuclear Test Ban Treaty', abridged by Trevor Findlay in edition No. 94. Findlay noted that the report revealed 'the surprising capabilities of a system that is still being established'. He continued, 'By examining the totality of the verification resources available to the international community, it not only provides a truer picture of verifiability but also draws attention to the fact that this compounds the uncertainty facing any potential treaty evader'. He concluded that a 'constantly evolving, technically advancing and multifaceted CTBT verification gauntlet is something that no state is ever likely to contemplate running'.

One distinctive feature of the Commission's report was that it also took into account so-called National Technical Means as an integrated part of the verification process. It is often overlooked that verification regimes are not stand-alone mechanisms or ultimate arbiters when states determine whether other countries behaviour is compliant or not. Of course, the independent and transparent nature of the verification regimes themselves makes such determinations more straightforward. Today, in most of the Western hemisphere, the CTBT's monitoring system is capable of detecting explosions as low as magnitude 3.4, which corresponds to an explosive force of about 50 tonnes in hard rock. This surpasses design expectations about 20 times over.

Currently, the treaty's future remains in limbo: 184 states have signed the agreement, and 168 has ratified it. However, eight countries will still need to ratify the accord for it to enter into force, namely China, Egypt, India, Iran, Israel, North Korea, Pakistan and the United States. Six of those states are presently nuclear armed. At some point in time, state parties will need to consider ways and means to bring this crucially important document into international law.

Strengthening safeguards: Work in progress

The IAEA's safeguards system already existed by the time of the first edition of this publication. However, the discovery of Iraq's clandestine, albeit largely undeveloped, nuclear weapons programme in the early 1990s highlighted the weaknesses of a safeguards system mainly based on declarations and material accountancy. These events prompted the IAEA Board of Governors to initiate, in 1993, a radical review of the safeguards system. The appraisal concluded with the decision to strengthen the safeguards system extensively, expanding its reach and the level of intrusiveness. The Additional Protocol (AP) was approved in May 1997 and was designed to provide the Agency with better tools to verify the absence of undeclared material and activities.

One remaining weakness in the system was the so-called Small Quantities Protocol (SQP), available to states with minimal or no nuclear material. The original protocol suspends the application of many provisions of the comprehensive safeguards agreement. This simplifies the implementation of safeguards in many states but also reduces transparency. In 2005, the IAEA Board of Governors decided that a revised standardized text that should be used for any future SQPs. According to the IAEA, 'the revised small quantities protocol reduces the number of provisions of the Compre-

hensive Safeguards Agreement (CSA) that are held in abeyance and key provisions related to reporting nuclear material and the conduct of inspections are operative'. In Trust & Verify No. 123, Jan Lodding and Bernardo Ribeiro described these efforts.

Safeguards implementation in Iran has been a concern since the mid-2000s, and something followed closely by Trust & Verify. On 14 July 2015, Iran agreed to accept extensive verification and monitoring on its nuclear programme in return for concessions elsewhere. The Joint Comprehensive Plan of Action (JCPOA) introduced several innovations to international safeguards. For instance, and as highlighted by Cindy Vestergaard in Trust & Verify No. 150, the deal 'goes beyond the CSA and AP and marks the first time that the IAEA will monitor a state's [uranium ore concentrate] UOC production and inventory in detail'. She also argued that 'the period of 25 years is also notable given that Iran's front-end activities will be monitored by the deal longer than for other stages of the fuel cycle'.

The future of the JCPOA is now in doubt, with the United States withdrawal from the agreement on 8 May 2018. It is, indeed, very likely that future editions of Trust & Verify will continue to devote column inches to the issue.

Monitoring a changing environment ....

A few months after our first edition, UK Prime Minister Margaret Thatcher spoke to the UN General Assembly on the topic of climate change. She warned about a 'change to the sea around us, change to the atmosphere above, leading, in turn, to change in the world's climate, which could alter the way we live in the most fundamental way of all'. For many years, Trust & Verify continued to report on developments in efforts to monitor and analyse our changing climate.

VERTIC set up an environment programme in 1991. It focused on the 1992 UN Framework Convention on Climate Change (UNFCCC), its 1997 Kyoto Protocol, proposals for the post-2012 climate change regime, and Reducing Emissions from Deforestation and Degradation and related areas. VERTIC's former Arms Control and Disarmament Programme and Environment Programme were merged to form the new Verification and Monitoring Programme in November 2012. While this new programme has mostly focused on arms control and disarmament matters, it has maintained a watching brief on the environment.

Reading through the Trust & Verify back catalogue, one thing stands out: the principal importance of verification and monitoring provisions for an effective multilateral response to climate change. In edition No. 111, Larry MacFaul put it starkly: 'Without an effective reporting system to provide information to allow parties' compliance and the overall progress of the regime to be assessed, the [UNFCCC] will stand no chance of having a real and sustained impact on climate change'.

… and much more

Trust & Verify also contains a wealth of information on conventional forces and progress in science and technology. The bulletin tracked the rise and de-facto fall of the 1990 Treaty on Conventional Armed Forces in Europe, which established limits on specific categories of conventional military equipment in Europe and had a well-functioning verification regime. However, complex and interconnected disagreements between Russia and members of the North Atlantic Treaty Organisation (NATO) ultimately resulted in the former limiting its participation in the treaty in 2007. While not formally withdrawing, Russia permanently suspended its involvement in the convention on 10 March 2015.

It is perhaps in the field of science and technology where progress has been most dramatic. At the end of the 1980s, typewriters were still in use, the World Wide Web did not exist, and mobile phones were primitive and bulky. The evolution of technology and its impact on verification is chronicled on our pages, although to a lesser degree since the organisation changed its long-form from the Verification Technology Information Centre in the late 1990s. Alongside data processing and storage, the bulletin has focused on satellite imagery. This tool was mostly held within the confines of governments 30 years ago but is today widely accessible at a low cost.

It is sometimes said that satellite imagery, often referred to as 'National Technical Means of Verification', enabled modern arms control. Today, with the increased accessibility of imagery products and ever finer resolutions, it is likely to be the technology that further enables non-governmental monitoring. In future editions of Trust & Verify, a new term may perhaps come into use: 'Public Technical Means of Verification'.

The next 30 years

Over several cool and unsettled summer days in 1989, Patricia Lewis (the then VERTIC director) and her staff sat down to write the first edition. Her team could hardly have imagined what the future would hold. In 2049, the Executive Director of VERTIC will hopefully get the opportunity to write an expose looking back over the next 30 years.

However, reading through some of the more recent pages of Trust & Verify, one gets the impression of political stagnation despite, or perhaps because of, unprecedented social, economic and technological developments elsewhere. Initiatives to control the most dangerous forms of weapons have both grown and contracted, and are now under pressure. There is little effective political action to slow down the pace of climate change.

One also cannot escape the feeling that the next 30 years will be critical for humanity, with climate change as the principal challenge. While this article did not spend much time on the matter, it is a topic that has been widely discussed in Trust & Verify and is set to loom even larger in future editions. By 2049, the Arctic sea-ice will have probably disappeared entirely in the Northern summer. It is equally plausible that Small Island Developing States, such as the Maldives, will have been relegated to the history books (presuming that books still exist in 30 years). Unfortunately, based on current trends, it is unlikely that nuclear weapons will have met a similar fate. After climate changes, nuclear weapons proliferation remains one of the other major challenges.

The next decade is also likely to continue to see severe challenges to the rules-based international order. It is expected to survive, but not without much scarring. Arms control is presently at low tide, but hopefully it will return, as the international community responds and adapts to the continuing sophistication of military force. Here, and elsewhere, automation is likely to continue to fuel societal and intergovernmental divisions. We are likely to see more powerful chipsets, more powerful computing, and a growing internet of things monitoring and measuring our environment. Whether machine intelligence is on the horizon, I think it is best left unsaid, but it is certainly within the realms of the possible.

Technology will also shrink. The future may well see nanobot technology become commonplace, and this will be associated with advances in medicine. It will also have repercussions for the Biological Weapons Convention, which has also been extensively covered in the pages of Trust & Verify and will continue to do so in the future.

The future will also have to accommodate ever higher energy demands, and this must lead to global changes in energy policies. While, nuclear energy, in some form, is likely to stick around for the next 30 years, alternative sources of energy will undoubtedly rise as technologies mature. Solar panels, for example, have become more efficient and driven down energy costs: in 1989, cutting-edge panels achieved 15 per cent efficiency, today, prototype panels have recorded a 44 per cent efficiency.

Perhaps most importantly, human beings should be able to see 'the big picture' at a much higher resolution than before. Humanity should be able to better understand what is happening to it and its environment. Whether it will be able to respond effectively to what it is observing remains to be seen. Hopefully, Trust & Verify will be continuing to assist in this endeavour as it has done so modestly but constructively over the past 30 years..

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The Comprehensive Nuclear Test Ban Treaty (CTBT) and On-Site Inspection (OSI): A Historical Perspective

Some hitherto classified British state papers on the 1958-1963 nuclear test ban treaty negotiations between the United Kingdom, United States and the Soviet Union are now open at the UK National Archives at Kew, London. One point of interest is their discussion of on-site inspection (OSI) issues. They make interesting reading now given how provisions on OSI eventually emerged some thirty years later when the 1994-1996 negotiations on the Comprehensive Nuclear Test Ban Treaty (CTBT) concluded. Since then there has been a further twenty years of work on OSI in the CTBT Organisation's (CTBTO) Preparatory Commission. The UK's 1963 appreciation, as does contemporaneous US research on OSI techniques, makes for an interesting comparison with OSI concepts and practicalities as they stand today in late 2018.

It is instructive to look at the information contained in the British state papers alongside reports of the US VELA UNIFORM test ban treaty verification effort, which ran sixteen separate projects to look at OSI practicalities of various techniques between 1960 and 1962. These were the first concerted practical attempt to address CTBT OSI issues (Bates, 1963). The sixteen techniques were clustered under three headings as follows:

- airborne survey—conventional aerial photography, airborne high-precision stereophotogrammetry; airborne magnetometer; airborne spectral reconnaissance system; airborne scintillometer;
- surface survey—visual inspection, changes in solid-state characteristics of minerals and rocks; monitoring of aftershocks, radon release from surface; gamma-ray surveys; soil density changes; reflectance changes from vegetation damage; induced earth currents in proximity of explosion cavity; and
- subsurface surveys—visual inspection of mine tunnels; gamma-ray logging; geochemical surveys using shallow bore-holes and seismic profiling.

Of the techniques tested by 1962, the US programme tentatively concluded that ten had utility under the conditions existing at the GNOME underground nuclear test (10 December 1961) in New Mexico and at the Nevada Test Site locale of the ANTLER nuclear test (15 September 1961). Promising techniques included visual and photographic reconnaissance, changes in solid-state characteristics of certain minerals, gamma ray surveys and after-shock monitoring. Problems still existed with deeply buried explosions, polar areas, and regions of shallow water cover (Bates and George, 1963). However, according to the 1963 testimony of Theodore A. George (see works cited below), VELA UNIFORM did not entail any integration of the inspection techniques, since the United States considered this too expensive to test under realistic field conditions at that particular time. Integrated application of on-site inspection techniques would not start until the 2000s, following the CTBT's signature, with the Integrated Field Exercise at the former Soviet Semipalatinsk Test Site in 2008, and at the much larger Integrated Field Exercise in Jordan in 2014. The extensive work undertaken by the CTBTO's Provisional Technical Secretariat since 1997 thus stands in contrast to the relatively limited practical work done on these issues in the 1960s.

In the spring of 1963, the UK and United States were making further final efforts to convince the Soviet Union to accept a quota of on-site inspections in a CTBT. Harold Macmillan (British Prime Minister and keen CTBT advocate) wanted to make progress and relied heavily on two key senior scientific experts to advise him on detection, identification and discrimination of underground seismic events; the requirements for effective verification set against these challenges and the risks involved in Soviet cheating under a test ban treaty. On 15 May 1963, Sir William Penney (former Director of the Atomic Weapons Research Establishment Aldermaston, but deputy-chairman on the UK Atomic Energy Authority in 1963) and Sir Solly Zukerman (Chief Scientific Adviser to the Ministry of Defence) sent the Prime Minister a memorandum on the test ban. This was in response to a series of questions that Macmillan had posed on 9 May 1963, and here is what they said on OSI (National Archives, 1963):

"Whatever the reasons may be for insisting on on-site inspection, it is difficult to see how an inspection could serve

any useful purpose unless some thorough inspection was carried out in the suspected area. Procedurally, any seismic event chosen for inspection would have to satisfy certain instrumental criteria, in respect of location and depth of focus, as determined from seismic records obtained at several seismic stations. On present technical evidence, we cannot assume exact location of a seismic event by long-range detection to within a radius of less than 10 kilometres, i.e. an area of about 300 square kilometres. In exceptionally favourable circumstances, or if good and reliable records were obtained from the seismic stations of the country where the event occurred, this area might be reduced to about 200 square kilometres; but in very unfavourable cases, it might be increased several times."

"If a suspected area of even the smallest size is to be effectively inspected, in the quickest possible time by a reasonably small group of inspectors, it is very important to have low level aerial inspection as a first approach to reducing and pin-pointing the most suspicious area. During this phase, photographic, magnetic and radioactive survey techniques would be used. Thereafter, very thorough ground inspection of the reduced area would be required to tabulate evidence of on-site activity and results characteristic of underground nuclear testing. For this purpose an inspection team would require portable seismographs, radioactive detectors, portable equipment for analysis of material samples collected in the area, and photographic equipment. Unless the suspected test had caused radioactive debris to escape above the surface, there would be no means, other than drilling, of obtaining final evidence necessary to establish the nuclear origin of an explosion. It is conceivable that detailed ground inspection might produce a justifiable need for drilling, but this should be requested only if the inspection had already provided positive grounds for doing so. In any case, a major difficulty would be to know exactly where to drill; and actual drilling for radioactive debris would not be lightly embarked upon in view of uncertainty, time and expense. Hence, we would suggest that the drilling stage in an inspection operation should not be pursued as a routine matter, but only after showing a well-founded suspicion produced by the inspection itself."

"... Having examined all relevant technical factors in the detection and identification of seismic events, we conclude ... So long as it is technically necessary to establish the cause of a seismic event, detailed visual on-site inspection will be necessary in selected cases and that over an area of at least 200 square kilometres."

UK-US efforts for a test ban in spring 1963 led to a high-level summit in Moscow in July in a final attempt to negotiate a CTBT; the UK and United States hoped for a comprehensive ban, but were prepared to settle for a partial test ban treaty limited to the atmosphere, underwater and in outer space. Khrushchev quickly rejected any on-site inspections, which the UK and United States deemed essential for any meaningful comprehensive test ban, so the Moscow summit focussed on a Partial Test Ban Treaty (PTBT) instead—the text of which was quickly agreed and opened for signature on 5 August 1963. On-site inspection was thus off the table until the 1977-1980 trilateral UK, US and Soviet Union tripartite nuclear test ban negotiations.

How did these UK perceptions and assessments in 1963 sit with the aforementioned contemporaneous VELA UNIFORM projects? The underlying concepts appear to have been the same, which should not be too surprising on two counts. First, a technical appreciation of the problems facing on-site inspection in a CTBT in light of the then available verification technologies and scientific knowledge of underground nuclear test observables could hardly fail to come to broadly similar conclusions. Second, given the very close UK-US collaboration on test ban treaty issues and negotiations between 1958 and 1963, technical exchanges between experts occurred frequently with shared perceptions often emerging as a result (see Walker, 2010). According to the 1963 testimony of Dr Charles C. Bates (see works cited), the US VELA UNIFORM programme built its OSI techniques projects:

"... around the concept that an on-site inspection would normally employ three phases. Phase I would involve the use of large-scale investigation techniques primarily suitable for use in a properly equipped aircraft. The purpose of these techniques would be to reduce very quickly the geographic area of 40 to 200 square miles in which the suspicious seismic events might have occurred to a more workable size such as square mile or so, for the surface inspection team to inspect in detail. Phase II would consist of a series of rigorously applied visual and geophysical inspection techniques aimed at identifying the most likely area or areas for drilling or, as the case may be, for positively identifying the suspicious

event as having been nonnuclear in origin without the necessity for drilling. Phase III would consist of drilling at the site of the supposed explosion cavity and obtaining sufficient evidence from either gas or core samples to establish without a doubt that a nuclear test ban violation had taken place."

When comparing efforts almost sixty years ago with those underway today to develop CTBT OSIs concepts, techniques and equipment, we can see that much of the original conceptual thinking is reflected in current practices and approaches (see, for example, CTBTO 2015 and 2017). Technology has moved on dramatically since 1962-63 as has our understanding of underground nuclear explosions and their observables. Verification capabilities are much greater now than in the early 1960s, but if the experts from that period—such as Penney, Zuckerman, Bates and George—were here today, then they would surely recognise that much of their original thinking on how a CTBT OSI should be conceived and executed still applies.

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Verification Watch

Iran tests the limits of the 2015 Nuclear Deal

Alberto Muti, Senior Researcher

Iran has declared it intends to breach some of the limitations on its nuclear activities set in the 2015 Joint Comprehensive Plan of Action (JCPOA). The declaration came on 17 June 2019, amid rising tensions between Iran and the United States, which left the nuclear deal in May 2018 and reintroduced sanctions in a campaign of 'maximum pressure' by the Trump administration. Iran has also expressed frustration with the European Union's inability to mitigate the effect of newly imposed US sanctions on its trade with European countries.

The 17 June declaration outlined two specific breaches of the JCPOA, and specified dates for both. By 27 June 2019, Iran announced that its stockpile of uranium enriched to 3.67% would surpass the limit of 300 kg; and by 7 July 2019, Iran would start enriching uranium above 3.67%, and up to 20%. At the time of writing, the 27 June deadline had passed with Iran close to, but not over, the 300kg threshold, which may still be surpassed in a matter of days.

The terms of the JCPOA were formulated around the concept of a 'breakout time', the amount of time Iran would need to accumulate enough weapons-grade material to produce one nuclear weapon, based on the accepted IAEA standard of a 'significant quantity' (SQ). For uranium, this is 25kg of material enriched at 90% or higher. The limits set by the JCPOA hold back Iran's breakout time to approximately one year. Both of these potential violations have an impact on Iran's possible breakout time.

Uranium enriched at 3.67% cannot be used to produce nuclear weapons, but it could be used as feed for further enrichment, cutting down significantly on the time required to reach 90% U235. However, the JCPOA-mandated 300kg stockpile would not be enough to reach 1 SQ. For that, Iran may have to accumulate roughly 1000kg or more of 3.67% material.

Enriching uranium beyond 3.67% and up to 20% will have a more profound impact on the breakout time. Assuming the intention to further enrich the existing stockpile to 90%, 20% enriched uranium requires a smaller starting stockpile to reach 1 SQ, as it contains a higher rate of the fissile U235 isotope. Moreover, early stages of enrichment require a much larger amount of work and power than later stages. Because of this, starting from a 20% enriched stockpile would significantly reduce the time required to reach 90%.

These violations will not put Iran within immediate reach of a nuclear bomb. However, they will shorten Iran's breakout time, possibly by a significant degree if taken in conjunction. Iran's claim is that by violating these provisions, it is not abandoning the JCPOA, but sending a signal, and that it would be willing to return to full compliance. Indeed, both measures could be reversed, by downblending enriched uranium or selling excess stock internationally—something Iran has noted it is currently prevented to do by US sanctions. Nonetheless, this strategy may still alienate some of the JCPOA's remaining parties (namely France, Germany, the United Kingdom, and the European Union), which may spell the end for the 2015 deal.

It is worth noting that other key limitations under the JCPOA have, so far, gone unchallenged. For example, Iran is still complying with the requirement to deploy no more than 5060 enrichment centrifuges, and limit itself to the older IR-1 type, instead of more efficient models it has developed. These limitations significantly reduce Iran's enrichment capacity, compared to the pre-JCPOA period.

Perhaps most importantly, Iran is still cooperating with the International Atomic Energy Agency (IAEA), allowing it to verify the breadth and scope of its nuclear activities. Withdrawal from IAEA Safeguards was a precipitating factor in previous crises between Iran and the West, and would likely be seen as a major cause for alarm today. For now, however, Iran is still subject to the most thorough set of international non-proliferation controls in the world, and any sudden move to further increase its capacity to produce nuclear weapons material would likely be detected. This may help the European parties make informed decisions about the scale and impact of Iran's violations, which may be key to finding a way through yet another Iran nuclear crisis.

Third session of the NPT PrepCom and the GGE report on the role of verification

Elena Gai, Researcher

The Preparatory Committee (PrepCom) for the 2020 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) held its third and final session from 29 April to 10 May 2019.

Today, it is recognised that without the implementation of strict verification procedures nuclear disarmament is unlikely to be achieved. This has been confirmed in a number of fora as well as in UN General Assembly Resolution 62/21 of 5 December 2007 on verification in all its aspects, and the 1990 and 1995 reports of the UN Secretary-General.

More recently, in Resolution 71/67 on nuclear disarmament verification, the General Assembly recalled 'the unequivocal undertaking of the nuclear-weapons States to accomplish the total elimination of nuclear weapons leading to nuclear disarmament', expressing its conviction that 'identifying and developing practical and effective measures of nuclear disarmament verification and monitoring' will 'foster confidence and facilitate efforts to achieve and maintain a world without nuclear weapons'.

The role of verification in advancing nuclear disarmament has been the object of an in-depth analysis by the Group of Governmental Experts (GGE) established in pursuant of this resolution. In their report published in May 2019, the participating experts concluded that advancing nuclear disarmament is an ongoing process and that all states could contribute to aspects of nuclear disarmament verification and to the development of verification methods and technologies.

A number of the 25 state participants submitted working papers to the GGE. Of particular interest is the Brazilian proposal for the creation of a group of scientific and technical experts on nuclear disarmament verification within the context of the Conference on Disarmament (CD). Such a group within the CD, or indeed within another part of the international disarmament machinery, could explore how an international agreement on nuclear weapons limitation, reduction or elimination could be supported by various verification mechanisms.

These measures would need to provide all states, with credible compliance assurances while also protecting sensitive information and meeting national safety and security requirements. Such a proposal is in keeping with the UN Secretary-General's Agenda for Disarmament, which was launched in May 2018 and outlines a set of practical measures across the entire range of disarmament issues. In this document, amongst other things, the Secretary-General calls on all states to 'work together to achieve concrete and irreversible steps to prepare for a world free of nuclear weapons, including by making the nuclear test ban permanent, developing approaches for nuclear disarmament verification [emphasis added] and ending the production of fissile material for use in weapons'.

During the NPT PrepCom, several states reiterated their support for sound and robust verification mechanisms while also pointing out that technical exchanges between nuclear-armed states and nuclear non-armed states are vital to enhance common understanding and build trust. Some states pointed to the complex nature of this exchange process given that a balance is required between the protection of proliferative information and the effectiveness of meaningful verification.

The necessity of further robust dialogue on technological challenges is also required by other elements that would indoubtly complicate future effective verification. These include emerging challenges to international safeguards, such as complex enrichment plants and new methods to produce isotopes, as well as being creative about future initiatives that might include verification of nuclear warheads dismantlement and supporting research into means of verifying fissile material disposition.

Although neither of the two draft texts produced by the Chairperson of the PrepCom could be adopted by consensus, the draft recommendations were put into a Chair's working paper to be submitted to the 2020 NPT Review Conference. The recommendations include States Parties reaffirming 'that effective and credible nuclear disarmament verification is essential to achieving and maintaining a world without nuclear weapons and welcome ongoing work in this regard aimed at promoting trust and confidence among States'.

Both the GGE report and the PrepCom Chair's working paper, are welcome developments in the quest to advance appropriate verification capabilities and to promote trust and confidence among nuclear-armed and non-nuclear-armed states.

Implementation Watch

Implementing the Legal Framework for the Management of Chemicals and their Wastes

Leanna Burnard, Legal Officer

Chemical, biological, radiological and nuclear (CBRN) events, whether intentional, accidental or natural, can cost lives and have a devastating impact on public health and the environment. In order to mitigate risks posed by CBRN incidents, the European Union CBRN Risk Mitigation Centres of Excellence (EU CBRN CoE) Initiative was established in 2010 to improve institutional capacities in countries around the world and thereby strengthen regional security. The CoE Initiative is run by the European Commission and utilises partner institutions to implement its projects. VERTIC is the lead partner on the legislative aspect of Project 61, which focuses on the sound management of chemicals and their associated wastes in Southeast Asia. In July 2019, VERTIC presented on the international legal framework for the management of chemicals and their wastes at the project's regional training workshop in Laos, which was organised by Public Health England.

Chemical production, use and disposal continue to increase worldwide, particularly in developing countries and countries with economies in transition. According to the Secretariat of the 2006 Strategic Approach to International Chemicals Management (SAICM), by 2020, developing countries will produce 31 percent and use 33 percent of global chemicals. In light of this, international laws and standards have been developed to address all aspects of chemicals management, reaching into the realms of disarmament, the environment and trade.

Firstly, the 1989 Basel Convention was adopted in response to the discovery of hazardous wastes in parts of the developing world that had been imported from abroad. The Convention applies to a variety of hazardous wastes, including chemical wastes. States Parties are prohibited from exporting such wastes to States Parties that have prohibited their import. Where a State Party has not prohibited their import, other States Parties are prohibited from exporting to them unless consent has been obtained. Following concerns that the Convention did not go far enough, the 'Ban Amendment' was introduced in 1995, banning all forms of hazardous waste movements from members of the Organisation for Economic Co-operation and Development (OECD) and the European Union, as well as Liechtenstein, to the remaining states. The Ban Amendment is not yet in force as it has not received the required number of ratifications.

The 1993 Chemical Weapons Convention (CWC) prohibits chemical weapons and regulates activities with toxic chemicals and their precursors. States Parties to the CWC undertake never in any circumstances to develop, produce, acquire, stockpile, retain, transfer, use or prepare to use chemical weapons. Article VII of the Convention requires States Parties to adopt the necessary measures to implement their obligations under the Convention at the national level. This includes prohibiting individuals from undertaking the activities prohibited by the Convention and adopting control mechanisms for activities with certain toxic chemicals.

The 1998 Rotterdam Convention establishes an international procedure for the transfer of hazardous chemicals between states. It applies to chemicals that have been banned or severely restricted in the States Parties, and severely hazardous pesticide formulations. The Convention does not ban the import and export of these chemicals completely, but it requires prior informed consent from importing countries. This empowers states to make informed decisions on which chemicals they want to receive and exclude those that they cannot manage safely.

The 2001 Stockholm Convention requires States Parties to restrict, reduce or eliminate persistent organic pollutants (POPs). POPs are toxic chemicals that are resistant to environmental degradation and are transported through air, water and migratory species, across international boundaries. POPs can cause cancers, birth defects and disruptions to immune and nervous systems in humans. The Convention lists these chemicals in its Annexes and seeks to restrict and eventually eliminate them from production, use, trade, storage and release. States Parties can register for exemptions to the Convention's requirements.

The 2013 Minamata Convention was created in response to the mercury poisonings of thousands of people in the town of Minamata, Japan, due to tainted industrial

wastewater. The Convention includes a ban on new mercury mines, the phase-out of existing ones, and the phase out and phase down of mercury use in certain products and processes. It also establishes control measures on emissions and releases of mercury and regulates artisanal and small-scale gold mining. In addition to these international conventions, there are various international instruments that set non-binding international standards for chemicals management. The 2017 United Nations Model Regulations on the Transport of Dangerous Goods establish a system for the classification, listing, packing, labelling and documenting of dangerous goods during transport. The 2017 Globally Harmonised System of Classification and Labelling of Chemicals (GHS) addresses chemicals classification and harmonised communication, through labels and safety data sheets, also during transport. Lastly, SAICM is a voluntary global policy that reflects environmental, economic, social health and labour aspects of chemicals management.

Moreover, regional European instruments can be a source of best practice. The 1992 UNECE Convention on the Transboundary Effects of Industrial Accidents aims to protect against industrial accidents that can have transboundary effects by preventing such accidents, reducing their frequency and severity, and mitigating their effects. The 2012 EU SEVESO III Directive similarly aims to prevent major accidents involving dangerous substances and limit the consequences of any such accidents. Finally, the 2007 EU Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) applies to all substances manufactured or imported into the EU in quantities of 1 tonne or more per year and makes companies responsible for understanding and managing the risks posed by chemicals.

The synthesis of these varied instruments produces a comprehensive system of standards to ensure countries have both the highest protection against and the most benefit from chemicals. Under Project 61, which lasts until August 2020, the partner countries and VERTIC will work on the national implementation of the international legal framework for chemicals with the aim of meaningfully managing the risks posed by chemicals in Southeast Asia.

Couple charged with BW offence in Germany

Thomas Brown, Associate Legal Officer

In February 2019, the German Federal Public Prosecutor charged a couple in connection with a plot to disseminate the toxin ricin as part of a planned terrorist attack. This followed the arrest of the two suspects in June and July 2018, after the police received information from a foreign security partner about a man ordering a large quantity of castor seeds online. When the police raided the couple's flat, they found over 3000 castor beans and 84.3 milligrams (mg) of ricin. Prosecutors allege that the couple had bought a hamster to test the effectiveness of the ricin before carrying out the attack.

Ricin is a toxin that can be produced from castor seeds. Small doses of less than 1mg of ricin can prove fatal to humans and no antidote currently exists. Any activity with this toxin that is not for peaceful purposes is prohibited by the Biological and Toxin Weapons Convention (BWC) and the Chemical Weapons Convention (CWC). The latter also lists ricin as a Schedule 1 chemical, thereby subjecting this toxin to international control measures.

As a State Party since 1983, Germany has implemented the BWC into its national legislation. It adopted the Law on the BWC in 1983 and amended its War Weapons Act to criminalise activities with biological weapons in 1989. In this case, the primary suspect was charged with intentionally producing a biological weapon under section 20 (1) of the War Weapons Act and the preparation of a serious violent offence endangering the state under section 89a of the Criminal Code, among other charges relating to attempting to join a terrorist organisation. The alleged accomplice was charged with supporting these acts.

The episode constitutes the first known case of a jihadist successfully producing ricin in Europe. The trial began in the Higher Regional Court of Düsseldorf on 7 June 2019 and is expected to continue until late August.

Compliance Watch

States step up regional maritime enforcement of UN sanctions against North Korea

Celeste Donovan, Researcher

A growing number of states, including Australia, Canada, New Zealand, the United Kingdom and the United States have deployed ships or maritime patrol aircraft to the Asia-Pacific region to conduct surveillance of North Korean vessels suspected of prohibited ship-to-ship transfers in breach of UN sanctions. These actions occur in the wake of setbacks in US-North Korean diplomacy, and follow the most recent UN Panel of Experts report from 5 March 2019, documenting a massive increase in illicit ship-to-ship transfers at sea which, the Panel said, render the latest United Nations sanctions 'ineffective'.

The shift towards a more strategic regional approach to sanctions enforcement in the Indo-Pacific region is foreshadowed in the US Department of Defense's first-ever Indo-Pacific Strategy Report released on March 2019. This report builds upon the theme of a Free and Open Indo-Pacific (FOIP) and poses the view that among other regional strategic concerns, North Korea poses a conventional threat to US allies, such as South Korea and Japan, and the US Indo-Pacific Command. The FOIP initiative focuses on maritime issues and aims to promote a 'network' of allies and partners to disrupt activities in breach of UN sanctions against North Korea, including 'illicit ship-to-ship transfers, often near or in Chinese territorial waters, and in the Yellow Sea'.

Highlighting this regional focus on sanctions enforcement, the US Department of Justice announced in May 2019 that it had filed a civil forfeiture case against North Korea's second largest vessel, the bulk carrier M/V Wise Honest (the 'Wise Honest') which it claims was used to 'illicitly ship coal from North Korea and to deliver heavy machinery to the DPRK'. The press release also states that financial payments for maintenance, improvements and equipment for the Wise Honest 'were made in U.S. dollars through unwitting U.S. banks' and so breached prohibitions on 'using the U.S. financial system'. As Cameron Trainer, Research Associate with the James Martin Center for Nonproliferation Studies points out, this case has broken new ground in sanctions enforcement in a number of areas, and so it may 'prove a useful typology for targeting other DPRK-linked vessels' as well as enhancing the ability of states to 'detect and seize proliferation-related goods, as well as respond to requests for legal assistance'.

In September 2018, New Zealand and Australia jointly announced plans to send 'three maritime patrol aircraft to Japan to assist with efforts to enforce United Nations sanctions against North Korea'. As part of their joint contribution, the New Zealand Government stated that it would deploy the Royal New Zealand Air Force P-3K2 maritime patrol aircraft, which will be based out of Japan, whereas the Australian government said it would be 'adding AP-3C Orion maritime patrol aircraft to conduct maritime surveillance to an existing aircraft deployed earlier in the year'. In April 2019, Australia announced it had further committed to 'deploying a P-8A Poseidon maritime patrol aircraft to Japan' which would aid its current maritime surveillance operations, and is reportedly 'one of the world's most advanced maritime patrol aircraft in service.'

In April 2019, the UK reported that it had deployed four separate Navy vessels since 2018 to aid international efforts at sanctions enforcement. According to the press release, on one of these voyages HMS Montrose and its Japanese partner vessels had tracked an illegal ship-to-ship transfer from the North Korean-flagged tanker SAEBYOL to a fishing vessel of unknown nationality. More recently, in June 2019, Canada announced it would be providing military aircraft, vessels and operational staff, operating from Japan to detect illegal activities undertaken in breach of UN sanctions, in particular ship-to-ship transfers of fuel and prohibited commodities.

In a statement released via the Korean Central News Agency, North Korea rejected its depiction as a 'rogue state' in the US Indo-Pacific Strategy Report and called it a 'provocation against the DPRK'. Nonetheless, as the US Secretary of Defense made clear, the Indo-Pacific region will continue to be its 'priority theatre' of engagement and it will endeavour to achieve its strategic objectives by demonstrating a more assertive approach to a range of issues in the region, including sanctions enforcement.

Signature withdrawal: observations on the US withdrawal from the 2013 Arms Trade Treaty

Cristina Rotaru, Researcher, and Thomas Brown, Associate Legal Officer

On 26 April 2016, the US President announced his intention to withdraw the US signature to the 2013 Arms Trade Treaty (ATT), pledging to formally notify the UN of this decision in due course—although to date, no formal notice has been given. What does it mean when a signatory state to a multilateral accord chooses to withdraw its support from that instrument, both from an international procedural perspective and from a domestic legal perspective?

To answer these question, at least in part, it is important to understand the background to the ATT's legal framework. As a multilateral, UN-backed treaty in force since 24 December 2014, the ATT sets the global standards for regulating transfers of conventional arms worldwide. To date, 104 states have joined the treaty, and 33 remain Signatory States. Pending formal withdrawal notification, the US continues to belong to the latter category—while it signed the treaty in 2013, it never ratified it. Therefore, the US cannot withdraw from the treaty, as it never joined it in the first place.

While the withdrawal provisions of the 1969 Vienna Convention on the Law of Treaties (VCLT), as set out in Part V, contain rules for termination or withdrawal that apply to states that have already ratified or acceded to a treaty, they fail to specifically address the procedure on signature withdrawals. A senior UN official with responsibilities in treaty oversight advised us that any state wishing to withdraw its signature from a treaty may send a communication to the treaty's Depositary (in this case, the UN Secretary-General) stating that it does not wish to honour the commitments it assumed on signature and does not intend to become a State Party. Rather than triggering the Depositary to remove the country from the list of signatories, such a development would be added as a footnote next to the name of the country. Interestingly, the UN official noted that the actual number of signatories to the ATT would remain unchanged even after a signature revocation, as past records cannot be erased or altered.

As it currently stands, like any other Signatory State that has yet to ratify the ATT, and until a formal notification is given to the UN of the withdrawal of its signature, the United States is bound under customary international law by the interim obligation (Article 18 of the VCLT) not to defeat the treaty's object and purpose. Article 1 of the ATT details the object and purpose of the treaty and all Signatory States are required to observe those guiding principles and commit themselves to not undermine them in any way.

From a public international law perspective, by unsigning the ATT, the United States will no longer be bound by the obligation to respect the object and purpose of the treaty. From a domestic legal perspective, in practice the substrata of national legislation would remain unchanged: the US already has domestic laws in place on matters governed by the ATT, incorporating many of the criteria specified in the ATT. Indeed, US domestic laws governing conventional weapons transfers, including on checks and verification processes, arms brokering and prohibitions of arms exports to certain countries, arguably extend beyond the ATT. For example, under Section 38 (a) (2) of the Arms Export Control Act of 1976, the decision whether or not to licence arms exports would take into account if 'the export of an article would contribute to an arms race, aid in the development of weapons of mass destruction, support international terrorism, increase the possibility of outbreak or escalation of conflict, or prejudice the development of bilateral or multilateral arms control or non-proliferation agreements or other arrangements'. This suggests that the Trump Administration's move to withdraw its signature from the treaty is largely symbolic.

Importantly, only a country that has already signed a treaty can 'ratify' it. Those that have not signed can 'accede' to, or 'approve' it depending on their constitutional processes for adhering to treaties. So, should the United States wish to re-join the ATT in the future, it would need to ratify, rather than accede to it.

While it is an unusual step to revoke a signature from a multilateral treaty, it is not entirely unheard of. Another example involves the Rome Statute of the International Criminal Court. Since its adoption in 1998, Israel, Russia, Sudan and the United States have all signed the treaty and subsequently communicated to the UN an intention not to become parties to the treaty and therefore not to be bound by its legal obligations. Even so, the US President's intention to withdraw the US signature from the ATT—a treaty for which universality continues to be a major challenge (a number of major importing and exporting states remain outside of the treaty)—raises many legal issues, both for domestic law, and for international adherence to multilateral instruments.

Science & Technology Scan

Technologies and techniques for detecting ballistic missile launches

Julia Masterson, Intern to the Executive Director

On 27 March 2019, India test-launched an anti-satellite weapon. On the same day, in his testimony before the Senate Armed Services Committee, US vice commander of Air Force Space Command Lieutenant General David D. Thompson confirmed that the 11th Space Warning Squadron at Buckley Air Force Base in Colorado was instantaneously attuned to the rocket in flight. Indeed, a global constellation of radars, sensors and satellites provides constant surveillance of the Earth's surface and for years has proved useful in detecting the launch of benign or offensive missiles across the world.

Effective missile defence relies heavily on the technical capability to detect a missile launch with enough time to respond appropriately, but the utility of detection technologies should not be considered limited to kinetic interception. Detecting the launch of a missile test allows insight into programme development which may later serve as a baseline for verification monitoring.

Generally speaking, the observables after a missile launch, for offensive or developmental purposes, share similar characteristics. Foremost, although varied by missile design, an unmistakable smoke plume is a key visual indicator of a missile launch and may be detected via overhead surveillance and satellite imagery. High-resolution images or by synthetic aperture radar could be examined for launch plumes The challenge, however, is that detection via imagery analysis is not instantaneous. Nevertheless, close retrospective examination of satellite imagery has recently been used to corroborate presumed North Korean ballistic missile tests and missile design, and has provided data which may be necessary for ensuring compliance with future arms control agreements.

Satellites may also be equipped with infrared sensors that reliably detect the heat emitted during a launch. Infrared surveillance can detect exoatmospheric launches whilst sensors promptly identify heat in contrast to colder temperatures in space, but infrared sensing is also used for ground-based surveillance and thus, depending on proximity, could ostensibly detect lower-altitude missile launches as well. The advantage of infrared sensing is evidenced by its use in early missile defence systems; the US Missile Defence Alarm System (MiDAS) employed infrared sensors to detect the heat signatures of Soviet rocket exhaust. Heritage systems like MiDAS struggled to credibly distinguish between the heat emanating from a missile and that from the reflection of sunlight on clouds, but today the upgraded Space Based Infrared System (SBIRS) provides consistent and decisive overhead infrared surveillance of both intercontinental and short-range missile launches.

In US-designed missile defence systems, SBIRS works in conjunction with ground-based radars that track missiles from mid-course. However, provided that a flight is launched within its range, a high-frequency ground-based radar could conceivably also detect a missile launch almost immediately.

Lastly, missile launches produce an infrasound that can be detected using specialised seismic monitoring equipment, such as the Comprehensive Test Ban Treaty International Monitoring System (CTBT IMS). Previous studies, including one published in Trust & Verify No.127, demonstrated that although less accurate than infrared sensors, infrasound monitoring can effectively observe the launch of a missile, albeit location dependent and with a delay. Like satellite imagery analysis, infrasound detection proves less useful in a crisis situation but can still provide a near-immediate means through which to verify a missile test and examine key data points.

The continued development of advanced missile programmes, especially among states outside of the Non-Proliferation Treaty, renders the challenge of launch detection even more salient; the ability to detect test launches will be as important for ensuring future international cooperation as it will be for defensive measures. As demonstrated by Lt. General Thompson's remarks, currently-deployed detection capabilities remain viable, despite the advent of new weapon systems, and can play a role in mediating future threats by reliably identifying test launches and providing observable data on design characteristics, flight patterns and more.

Nuclear monitoring with neutrinos

Grant Christopher, Senior Researcher

The use of neutrinos to monitor nuclear activities has been somewhat of a holy grail for verification (see Trust and Verify Nos. 150, 135 and 123). Can neutrino detectors be used to monitor nuclear facilities or nuclear weapons tests? Ghostlike, neutrinos pass through nearly all materials without a trace and so are difficult to detect. Once they are born, the typical neutrino will continue moving in a straight line, forever, until the heat death of the universe. We are surrounded by a constant background of neutrino emissions from natural radioactive decays in the Earth's crust. Since the dawn of the nuclear age this background has been supplemented by neutrino emissions from human nuclear activities. In 2015, for the first time, an extraordinary global map of neutrino emissions was produced by researchers at the National Geospatial Intelligence Agency. This map showed the natural background emissions of neutrinos, but also concentrated spots of emissions from nuclear reactors.

If neutrinos can be detected they can provide information about the nature of nuclear activity that produced them. As neutrinos are so hard to detect, the best method is to install a detector close to the facility to be monitored. Of course, that is complicated if a facility's location is unknown or access to the site is not possible. The second-best method is to increase range by constructing large detectors. One of the largest neutrino detectors in the world, the Super Kamiokande experiment in Japan, is 850 km away from North Korea's Punggye-ri test site. The detector is a steel tank filled with 50,000 tons of ultra-pure water, instrumented with photomultiplier tubes, located 1000 metres underground in the Kamioka mine. When a neutrino passes through the water it produces a blue light known as Cherenkov radiation, which is detected by the photomultiplier tubes and attributed as a neutrino.

In principle, neutrino monitoring could be used to support the Comprehensive Test Ban Treaty (CTBT) by detecting weapons tests, confirming their nuclear nature and estimating their yield. A team led by MIT's Rachel Carr has assessed the suitability of a Super-Kamiokande-like detector to monitor North Korean nuclear tests. A 1 kT nuclear test will rapidly emit 1024 isotropic neutrinos; but previous work has already established that it would require a detector hundreds of times larger than Super Kamiokande to detect a test without prior notification. A key insight of Carr et al. was to try and simply confirm the nuclear nature of a suspected test, using a seismic event as a trigger. Unfortunately, Super Kamiokande is both too small and too far away to detect enough neutrinos to record a suspected test. Even considering newer planned detectors neutrinos are not expected to assist CTBT monitoring.

In a 2019 publication in Science & Global Security, another team led by Carr claims a neutrino detector, that could be transported on the back of a truck, could be installed at Yongbyon to monitor activity at the 5 MWe reactor, or the nearly completed experimental light water reactor, as part of a future verification regime. Neutrino detectors, due to the impossibility of shielding neutrinos, can be installed outside facilities. They can be used to verify a reactor's operational status, detect reactor power levels and assess the accumulated plutonium content. The authors claim that only 12 months would be required to construct such a detector at a reasonable cost.

The technology is approaching maturity. Using scintillators, rather than large water detectors, proof of concept facilities have been constructed, such as the Precision Oscillation and Reactor Spectrum Experiment (PROSPECT) at Oak Ridge National Laboratory, for a cost of less than $5 million within one year.

Measuring activity at reactors with neutrinos requires the steady accumulation of data over time. To detect the diversion of a core containing 8 kg of plutonium (1 significant quantity by IAEA definitions) would require 200 days of data collection, using a 20-ton detector deployed relatively close to the core. Larger detectors, constructed farther away, could detect the operation of the 5 MWe reactor at Yongbyon in 250 days, which is still timely as it takes approximately 400 days to breed 8 kg of plutonium.

The addition of neutrino monitoring to a future verification regime, based on this work appears to be feasible and practicable.

Centre News

Work in the centre of the Centre

Andreas Persbo and Helen Cummins

In April, we appointed Julia Masterson to be our first intern paid a London Living Wage. Previously, we had, like so many other charities, opted to pay a symbolic stipend covering the intern's travel expenses and lunches. Our decision to pay full salary is in recognition of the excellent work and the professionalism of our interns. We hope others will follow.

While most of the central team's time was devoted to internal business, we also lent support to the programmes for both project implementation, mostly on our DPRK related project, and fundraising. We hope to have good news to impart, yet again, on the latter front in the coming months.

On 26 April, Andreas Persbo attended a Foreign & Commonwealth Office briefing on the third and final NPT Preparatory Committee. On 2-4 May 2019, we travelled to New York to participate in a side-event at the PrepCom, sponsored by the United Nations Office for Disarmament Affairs. This was followed by a debriefing workshop, with select civil society organisations, held at King's College London on 15 May 2019.

On 22-23 May 2019, Andreas Persbo attended a two-day seminar on nuclear safeguards held at the Vienna Centre for Nuclear Disarmament and Non-Proliferation (VCDNP), where he delivered two presentations.

On 11-12 June 2019, Mr Persbo attended the EU Non-Proliferation Consortium's consultative meeting where he, also, had dinner with Elena and Nikolai Sokova. Ms Sokova will resume her duties as Executive Director of the VCDNP. The Centre has been a valued VERTIC partner for years, and we look forward to continuing our productive relationship in the future.

Finally, Mr Persbo travelled to Stockholm, Sweden, on 17-19 June 2019 to attend a workshop on North Korea, hosted by the Stockholm International Peace Research Institute and organised by the International Institute for Strategic Studies.

The Senior Management Group held two meetings under the period. The Executive team also devoted considerable time on defining the role of our prospective Director of Finance. We are presently assessing applicants.

Verification and Monitoring

Larry MacFaul, Noel Stott, Grant Christopher, Alberto Muti and Elena Gai

The team has continued to engage with partners in South America and Africa on strengthening regional capacity on nuclear disarmament verification. In May, VERTIC, in co-operation with UNODA, hosted a seminar on 'The Future Direction of Multilateral Arms Control' in New York during the NPT Preparatory Committee. We also made progress on another initiative to develop a new set of methodologies to assess the nuclear fuel cycle and its potential for weapons production.

The team continued work to strengthen international investigations into the alleged use of biological weapons. In particular, we focused on developing materials for our upcoming Table Top Exercise, which aims to identify improvements to the current framework for responding to such attacks. During this period, the team provided a briefing on our progress to government experts in the UK Foreign and Commonwealth Office (FCO).

In April, Andreas Persbo, Larry MacFaul and Alberto Muti attended a briefing by the FCO ahead of the 2019 NPT Preparatory Committee. In May, team members also attended a Wilton Park conference on nuclear security and technology and a RUSI meeting on the recent House of Lords enquiry into nuclear risk, disarmament and the NPT. Also in May, Andreas Persbo presented at a meeting organised by the Vienna Center for Disarmament and Non-Proliferation on 'IAEA Safeguards: Staying Ahead of the Game', while the team prepared material on VERTIC's safeguards experience for discussion. Elena Gai, Larry MacFaul and Andreas Persbo also attended the UK launch of 'Gender Championship in Nuclear Policy'.

At the end of May, a cross-programme panel from VERTIC hosted a group of visiting students and tutors from the University of Maryland, USA. The visitors were given an insight into VERTIC's work and impact.

We are very pleased to announce that Dr Grant Christopher has joined the VM Programme as Senior Researcher. Grant holds a Ph.D. in Experimental Particle Physics from New York University, and formerly worked for Ridgeway Information, King's College London, and the European Organization for Nuclear Research (CERN).

National Implementation

Sonia Drobysz, Yasemin Balci, Leanna Burnard and Thomas Brown

Since the last edition of Trust & Verify, the National Implementation Measures (NIM) team has worked across a number of projects to improve the implementation of international instruments related to chemical, biological, radiological and nuclear (CBRN) weapons and materials. The NIM team welcomed a new Associate Legal Officer, Thomas Brown, and is temporarily without Programme Director Sonia Drobysz while she is on maternity leave. During this period, work continued on the three EU CBRN Centres of Excellence Projects (CoE) that the NIM team is currently involved in. Senior Legal Officer Yasemin Balci and Legal Officer Leanna Burnard attended Steering Group Committee Meetings in Belgium in June 2019 for Projects 53 (biosafety and biosecurity in Central Asia) and 61 (management of chemicals in Southeast Asia). At these meetings they provided updates on the progress made on the projects and communicated the NIM team's plans for future work.

The NIM team is close to completing Project 53 and working towards the final analyses of legislation concerning the Biological Weapons Convention, International Health Regulations and Codex Alimentarius in Central Asian countries. Moreover, the NIM team is compiling trends in national implementation in a report on national and regional strategies to strengthen legislation on biosafety and biosecurity in Central Asia.

Under EU CBRN CoE Project 61, Leanna led a regional workshop on international legal frameworks for chemicals in Vientiane, Laos during 2-3 July 2019, where she provided training on the national implementation of international instruments relating to chemicals management. Thomas and Leanna further carried out legislative analyses under Project 61.

Similarly, Yasemin and Sonia continued to undertake legislative assessment activities under EU CBRN CoE Project 67 on CBRN waste management in South East and Eastern Europe.

Additionally, the NIM team continued to work alongside the International Federation of Biosafety Associations (IFBA) and the Malian Association for Biosafety and Biosecurity (MABB) on a project funded by Global Affairs Canada to strengthen biosafety and biosecurity in Mali. Sonia held meetings throughout this period with project members, to facilitate the legislative assistance in this field.

Special Projects

Angela Woodward, Celeste Donovan and Cristina Rotaru

The Special Projects team continued its work on North Korean sanctions-related research and workshops during the first two quarters of 2019, maintaining a particular focus on maritime sanctions and related legal issues.

Programme Director Angela Woodward participated in workshops on North Korean maritime sanctions implementation held in Nadi, Fiji during 6-7 March, and Manila, Philippines during 11-13 March, where she gave presentations on states' maritime-related obligations under the UN Security Council Resolutions concerning North Korea, and provided training to workshop participants on implementing these requirements in national regulatory frameworks.

On 18-19 March, Angela also participated in a conference hosted by the New Zealand Centre for Global Studies on 'The Legal and Political Implications of the Treaty on the Prohibition of Nuclear Weapons' in Wellington, New Zealand, where she delivered a presentation titled 'Verification of denuclearization'. On 28 May, Angela participated in a civil society meeting with the New Zealand Under-Secretary for Arms Control and Disarmament, Fletcher Tabuteau, held in Wellington, during which she discussed the current status of nuclear disarmament verification activities. Angela also worked on VERTIC's Strategic Plan, with fellow Senior Management Group staff.

On 15 April, Celeste Donovan, Researcher and Angela jointly attended a briefing in Christchurch by Mary Wareham, Advocacy Director in the Arms Division, Human Rights Watch, Washington on Lethal Autonomous Weapons. On 26 June, Celeste and Angela met with Natasha Barnes Dellaca, co-founder and Communications and Strategy Director of EPIC, Westport Innovation Hub, in Christchurch to discuss the implications of crypto-currencies and blockchain technology for verification.

In London, Cristina Rotaru, Researcher, attended a meeting with a visiting Australian government official to discuss topical CBRN non-proliferation issues on 28 May, and a working group discussion on WMD issues organized by the School of Public Policy at the University of Maryland, United States, on 29 May.

Angela was awarded her Diploma in International Nuclear Law from the University of Montpellier, France in June.

Grants and administration

Some funding news ...

In June, the Special Projects Programme signed two grant agreements for $578k and $138k respectively for its work on multilateral sanctions. This will allow the programme to continue its work well into 2020. Regrettably, we also heard from the Foreign & Commonwealth Office that they would not be in a position to fund our work on the Additional Protocol in 2019 and early 2020. We are looking at options in which we can keep this work alive, and look forward to submitting new proposals to the FCO next year.

... and some staffing news

As has been reported earlier, Dr Grant Christopher, a PhD holder in Experimental Particle Physics at New York University, joined us in June 2019. Moreover, we were pleased to welcome and host Ms Julia Masterson, an MA candidate in Non-Proliferation and International Security at King's College London, to the organisation. Ms Masterson will be with us until late July 2019, after which she will finish her studies and then take up a position with the Washington-based Arms Control Association. In coming weeks, she will be joined by our second intern on the new scheme, Ms Anuradha Damale, who is at present with the University of Sussex's Science Policy Research Unit (SPRU).

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VERTIC is an independent, not-for-profit, nongovernmental organisation. Our mission is to support the development, implementation and effectiveness of international agreements and related regional and national initiatives, with particular attention to issues of monitoring, review, legislation and verification. We conduct research, analysis and provide expert advice and information to governments and other stakeholders. We also provide support for capacity building, training, legislative assistance and cooperation.

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EDITION NO. 164

Edited by Dr Ian Davis
Produced by Andreas Persbo

ORIGINAL DESIGN

Richard Jones, Studio Exile.

SUBSCRIPTION

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PUBLICATION DISCLOSURE STATEMENT

This paper is principally produced through research support from the Joseph Rowntree Charitable Trust (JRCT). The terms of this arrangement have been reviewed by VERTIC. and is considered compliant with the charity's objects as defined in Article 4 of the Articles of Association (2011).